Routledge
Taylor & Francis Group

International Journal of Science Education

ISSN: 0950-0693 (Print) 1464-5289 (Online) Journal homepage: https://www.tandfonline.com/loi/tsed20

The role of empathy for learning in complex Science|Environment|Health contexts

Albert Zeyer & Justin Dillon

To cite this article: Albert Zeyer & Justin Dillon (2019) The role of empathy for learning in complex Science|Environment|Health contexts, International Journal of Science Education, 41:3, 297-315, DOI: 10.1080/09500693.2018.1549371

To link to this article: https://doi.org/10.1080/09500693.2018.1549371

Published online: 01 Dec 2018.

INTERNATIONAL JOURNAL OF SCIENCE EDUCATION
2019, VOL. 41, NO. 3, 297–315
https://doi.org/10.1080/09500693.2018.1549371

The role of empathy for learning in complex Science|Environment|Health contexts

Albert Zeyer [a] and Justin Dillon [b]

[a]Department of Health Professions, Bern University of Applied Sciences, Bern, Switzerland; [b]School of Education, University of Exeter, Exeter, UK

ABSTRACT

Recent research on motivation to learn science shows that science teaching usually supports students' systemising, but not their empathising cognition. In this paper we argue that empathy, with due caution, should be emphasised in science learning more seriously and consistently, particularly in a Science|Environment|Health pedagogy that aims at fostering the mutual benefit between the three interlinked educational fields. After briefly recapitulating research results about the empathising-systemising (E-S) theory and motivation to learn science, the paper describes the science of empathy and then reflects on the opportunities and challenges of introducing empathy into science teaching. Many studies of effective science learning can be found that involve empathising, though this usually is not made explicit. Thus, bringing empathy into play sheds another light on successful science learning and helps in unfolding its full potential. Moreover, considerations about the role of values in science education entail the insight that, when it comes to complex socio-scientific issues, including empathy is not only useful, but actually vital. The concept of reflective equilibrium, taken from applied ethics, provides a framework for the consideration of both systematic and empathic aspects in science teaching. This undervalued approach promises to involve all students and is therefore a genuine *science for all* approach.

ARTICLE HISTORY
Received 21 January 2018
Accepted 14 November 2018

KEYWORDS
Empathy; motivation; complexity; socio-scientific issues; values; ethics; health; environment

1. Introduction

In this paper, we make a case for including empathy more seriously and consistently, but with due caution, in science learning. Figure 1 represents a structural equation model from a recent series of studies (e.g. Zeyer, 2017) that investigated motivation to learn science in the theoretical framework of the Empathising-Systemising (E-S) theory (e.g. Baron-Cohen, Knickmeyer, & Belmonte, 2005). According to this theory, there are two fundamental psychological dimensions: systemising and empathising. Systemising describes a person's ability to perceive physical things and understand them and their function in

CONTACT Albert Zeyer albert.zeyer@bfh.ch Department of Health Professions, Bern University of Applied Sciences, Murtenstrasse 10, CH-3008, Bern, Switzerland

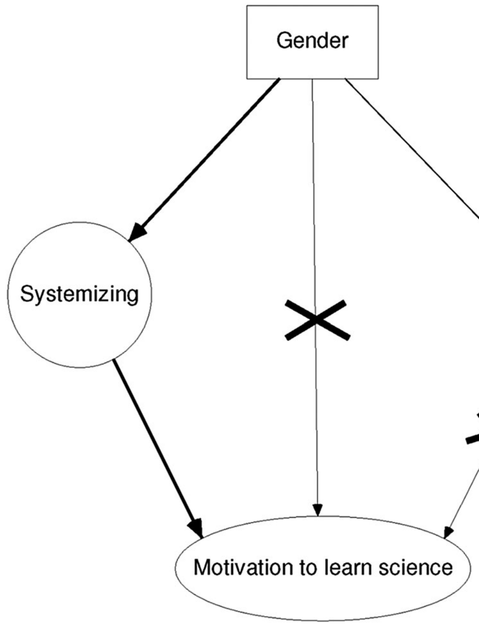

Figure 1. The Gender-Systemising-Empathising-Motivation (GSEM) Model (adapted from Zeyer, 2012).

the context of a system. The second cognitive dimension, empathising, is the ability to identify and perceive mental states (ibid.).

The studies mentioned above used structural equation modelling in order to investigate the relation between gender, systemising, empathising, and motivation to learn science. Figure 1 displays the resulting model that has consistently been confirmed, particularly in a large cross-cultural study (Zeyer et al., 2013) involving more than 1200 students from four countries (Malaysia, Turkey, Slovenia, and Switzerland).

Imagine students' systemising and empathising cognition for a moment as two open gates towards motivation to learn science (though, of course, in Figure 1, the pathways represent correlational couplings). One gate, systemising, is usually wide open to science education. The other door is not really closed, but it is neglected—and often ignored—because empathising is not usually seen as being helpful for doing science. It may even be considered an obstacle. We will argue that there are indeed reasons why empathy in science education has to be handled with care. But in complex situations as in Science|Environment|Health issues (Dillon, 2012), where scientific knowledge is vital for pragmatic decision making, empathy is not only helpful for getting students on board, it is a core strategy for engaging with controversial situations.

The model in Figure 1 includes two pathways. The first is the Gender-Systemising-Motivation (GSM) pathway. Here, systemising has a high impact on motivation to learn science, while the impact of gender is only indirect. The importance of the GSM pathway for science learning has been discussed in detail elsewhere (e.g. Zeyer, 2017). Gender is much less important for motivation to learn science than a systemising cognition. Students who strive for understanding phenomena in terms of a system, and for predicting and controlling systems in terms of input, action, and output, are motivated to learn science—independently from their gender. Thus, science teachers, instead of caring about a 'girls' science' (however it is conceptualised), should primarily keep in mind the systematic challenge of their teaching materials and match it to their students' level of systemising, be they boys or girls.

The second pathway, Gender-Empathising-Motivation (GEM), is the major focus of this paper. In contrast to the high impact of systemising on motivation to learn science, the effect of empathising was consistently absent (i.e. small and not significant). In other words, in these studies, empathising had no effect at all on motivation to learn science. This finding can be interpreted in two ways. The first interpretation is that simply empathising has no impact on motivation to learn science, because science is mostly about physical things and *prediction and control*. However, a recent study (Zeyer, 2017) suggests that the situation is more complicated. The study differentiates between physics, chemistry, and biology, that is, it tests the GSEM model for each subject separately. For physics and chemistry the model was, once again, highly fitting, and it confirmed the already known impacts of systemising on motivation. However, for biology, systemising, surprisingly, had no significant effect on motivation, and neither had empathising. We will come back to the interpretation of these results later in this paper.

The second interpretation, favoured here, is that science teaching often fails to take empathisers' needs into account. In other words, it ignores an important opportunity to foster the motivation to learn science of many students. Only 5% of an average student population shows high systemising and thus is motivated to learn science by the GSM path (Zeyer, 2012). All the other students would benefit from an activation of the second pathway, the GEM path. In particular, female students would profit because they, as the GEM path shows, tend to be empathisers, but so would empathising boys, a not-so-small minority of male students (see below).

In the next section, we will start by briefly recapitulating the E-S theory in order to provide the reader with a basic theoretical framework. We then will give a description of what scientifically is known about empathy, before we embark on reflecting about opportunities and dangers of introducing empathy into science learning.

2. The empathising-systemising theory

The Empathising-Systemising theory was originally proposed by Baron-Cohen et al. (2005). The two fundamental psychological dimensions: systemising and empathising relate to the 'consciousness of a physical world' and the 'consciousness of a mental world' respectively (Baron-Cohen, Wheelwright, Stone, & Rutherford, 1999).

Systemising describes how a person strives to explain physical things in terms of a system, that is, an entity consisting of parts and their interactions. The goal of this cognitive dimension is to analyse systems in terms of a tripartite structure of input – activity – output and thus to identify a set of determining rules. These rules can then be used in order to predict and control the behaviour of the system – the core aim of systemising.

In contrast, empathising strives to identify, perceive, and understand mental states. Baron-Cohen and colleagues characterise empathising as involving a cognitive and an affective component (Baron-Cohen & Wheelwright, 2004). Later we will show that this view is in line with today's predominant scientific empathy concepts. The cognitive component of empathy, also called Theory of Mind (ToM) consciously understands other people's feelings (affective ToM) and thoughts (cognitive ToM). The affective component includes emotional reactions to other people's mental conditions.

The basic principle of the E-S theory is that we all use both of these psychological dimensions, although one generally predominates. On average, women are empathisers (i.e. their empathising cognition is predominant, E > S), and males are systemisers (i.e. their systemising cognition is predominant, S > E) (Baron-Cohen et al., 2005). Empirically, this constellation has been confirmed many times – most recently in a large US study of more than 5000 people (Wright & Skagerberg, 2012) and in a Finnish study that involved more than 3000 Finish volunteers (Svedholm-Häkkinen & Lindeman, 2016). Not surprisingly criticisms of the E-S theory were that it reinforced long-standing prejudices about 'empathising women' and 'systemising men'.

On the face of it, this simple criticism seems to be true but actually, and importantly for our work, quite the opposite is the case, because statistically, these effects are only of medium size. In the US study, for example, Wright and Skagerberg calculated that if you meet an empathiser, the chance that she is a woman and not a man is 2:1, and *vice versa*. Thus, instead of cementing old prejudices, these empirical findings cast a spotlight on systemising females and empathising males. Both groups are considerably large minorities that remain, in a gender-oriented approach, largely underestimated (Svedholm-Häkkinen, Ojala, & Lindeman, 2018). It is central to our reasoning that science education should not forget about the systemising girls and the empathising boys.

3. Empathy

3.1. History and definition

Though the word empathy has its linguistic roots in ancient Greek—from *empatheia* (passion), composed of '*en*' (in) and '*pathos*' (feeling)—the scientific history of empathy is relatively short and goes back to its use in philosophical aesthetics (Singer & Lamm, 2009). It was the psychologist Edward Titchener (1867–1927) who introduced the English term 'empathy' in 1909 (Stueber, 2017). Titchener translated the term from the German '*Einfühlung*' (or 'feeling into'). Empathy was originally proposed for describing a tool for analysing both works of art and natural phenomena. Only later did it come to denominate a more specific mechanism for recognising each other as 'minded creatures' (ibid.). There are almost as many conceptual definitions of the term as there are scientific, and non-scientific, discourses in the field. Nevertheless, here, we provide a state of the art consensus upon which most researchers agree today, including Baron-Cohen and his group, the authors of the E-S theory.

At a basic phenomenological level, empathy is an affective response to the directly perceived, imagined, or inferred feeling state of another being (Singer & Lamm, 2009). De Vignemont and Singer (2006, p. 435) define empathy as follows:

> We 'empathise' with others when we have (1) an affective state (2) which is isomorphic to another person's affective state, (3) which was elicited by observing or imagining another person's affective state, and (4) when we know that the other person's affective state is the source of our own affective state.

3.2. Three aspects of empathy

The concept probably most accepted in the social sciences, neuronal sciences, and philosophy of mind dissociates empathy into emotional empathy and cognitive empathy, and divides the second again into affective Theory of Mind (affective ToM) and cognitive Theory of Mind (cognitive ToM) mentioned above. To put it simply, emotional empathy feels the feelings of others ('I feel her distress'), affective ToM thinks about feelings of others ('I know that she is feeling anxious today'), and cognitive ToM thinks about the thinking of others ('I know that she is thinking about the accident') (Dvash & Shamay-Tsoory, 2014).

Neuroanatomy actually suggests that there are indeed different anatomical substrates for these three types of empathy. Emotional empathy seems to activate limbic neuronal areas (Amygdala, Insula and anterior cingulate cortex), while both aspects of cognitive ToM are associated with neo-cortical structures, namely affective ToM with ventromedial prefrontal cortex, and cognitive ToM with medial prefrontal cortex and superior temporal sulcus (Dvash & Shamay-Tsoory, 2014). We now briefly explain the three types of empathy, that is, emotional empathy, affective ToM, and cognitive ToM, in more detail (see also Figure 2 below).

3.2.1. Emotional empathy

Emotional empathy is illustrated by the remark: 'I feel her distress'. It is a mostly sensory-driven process in which affective states are induced in the observer by means of bottom-up perception processes. Consistent evidence suggests that sharing the emotions of others is associated with automatic activation in neural structures that are also active during the

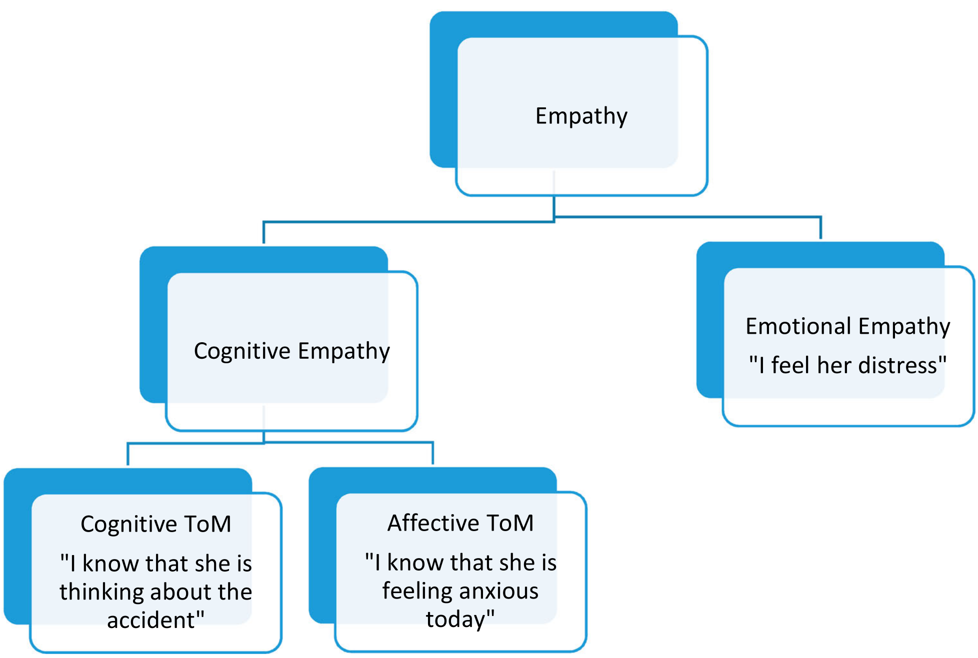

Figure 2. The three types of empathy (adapted from Dvash & Shamay-Tsoory, 2014).

first-hand experience of that emotion (Singer & Lamm, 2009). The term 'mirror neurons' captures this significant overlap between neural areas of excitation. It has been established for our recognition of another person's actions and their emotional states as well (Stueber, 2017).

3.2.2. Cognitive empathy

Cognitive empathy enables humans to engage in the mental process of adopting another individual's psychological perspective. This process may be defined as an active attempt by one person to get 'inside' another's mind or to approach someone's thoughts, intentions, or beliefs mentally through a deliberate intellectual effort. This function, known as theory of mind (ToM), enables an individual to understand another person's behaviour and to react accordingly. It is an ability that usually develops in people as they move from early youth to adulthood.

Results of neuroscience studies indicate that cognitive empathy itself is differentiated at least into an affective and a cognitive dimension (thinking about feelings v. thinking about thoughts, intentions, or beliefs). Functional magnetic resonance imaging and transcranial magnetic stimulation (TMS) support this differentiation (Dvash & Shamay-Tsoory, 2014).

Affective ToM ('I know that she is feeling anxious today') assumes that the mental states of others are represented by tracking or matching these states with resonant states of one's own (Singer & Lamm, 2009). This concept is based on the so-called shared representations account of social interaction and intersubjectivity. It has become the dominant explanation of how people understand other people's mental states: to understand what another person is feeling, we simulate their feelings using our own affective programmes (ibid.).

Cognitive ToM ('I know that she is thinking about the accident') is also called Theory theory (TT). Theory theorists hold that people somehow acquire a theory of the mental realm (Dvash & Shamay-Tsoory, 2014). They assume that we understand mental concepts by an implicit grasp of their role in a folk psychological theory and its law-like psychological generalisations. Mental states are attributed to other people as a theoretical inference (Stueber, 2017).

Figure 2 summarises again the concept of empathy used in this paper.

4. Can empathy play a role in science learning?

In this paper we ask two fundamental questions: Can empathy play a role in science learning, and if so, should it play a role? In this section, we discuss the first question, based on empirical results from research into science learning. We argue that, already, in the science education literature, many successful interventions involve empathising, though this usually is not made explicit. In other words, bringing empathy into play sheds another light on approaches to science learning that aim to foster the motivation and the interest to learn science. Explaining their impact in terms of their empathising qualities helps to explain their full potential.

4.1. Emotional empathy – learning in social contexts

Empathy is involved in any learning approach that offers the opportunity to activate 'mirror neurons'. Fostering social activities, making contact between students, and students and the teachers, all these need and activate empathising skills. Usually, however, empathy as a factor of motivation is not explicitly taken into account.

For example, Itzek-Greulich and Vollmer (2017) investigated learning in science centre outreach labs and found that students particularly appreciated practical work especially when it was carried out as group work. However, they did not elaborate on this last specification and, in particular, did not include social aspects of group work and the need of empathizers for social interaction into their discussion of motivation. Similarly, Martin, Durksen, Williamson, Kiss, and Ginns (2016) found that a tripartite engagement framework including cognition, behaviour and emotion led to improved motivation for science learning in museum visits. However, as they make explicit, they did not disentangle the role of emotion from the two other dimensions of engagement, nor did they specify empathic aspects of the emotional dimension. Bryan, Glynn, and Kittleson (2011) found that students, among other aspects, wanted more social interaction and more collaborative projects in their science classes. However, they only interpret this finding in terms of a well-known characteristic of 14–16 years old, without particularly focusing on the needs of empathizers. Polman and Hope (2014), who investigated youth engaged in creating science news stories found that an important driver for situational interests were life events (an aunt diagnosed with a rare disease, a student's experience with cupping), peer community (where teen pregnancy was prevalent), and cultural community (where cupping was an accepted alternative medicine practice), yet, again, they refrained from connecting these findings to emotional empathy. Keller, Neumann, and Fischer (2016) found that teacher pedagogical content knowledge mainly influenced student learning whereas teacher motivation mainly influenced students' interest, and that there were no cross-effects between the two. However, when they discuss the core effect of teachers' enthusiasm on students' interest, they do not use the concept of emotional empathy although it would have been self-evident. The same holds for Simpkins, Price, and Garcia (2015), who showed that parents' positivity, co-activity and school-focused behaviours predicted higher adolescent motivation for learning all three sciences. While the authors are very detailed about the empirical effects, they abstain from discussing underlying mechanisms and, in particular, do not use the concept of (emotional) empathy.

Why is it that empathy does not play a role in all these studies? There are, of course, many other reasons that explain the positive effects. However, they all benefit from the activation of emotional empathy in one or another way. One reason could be that, seen in this light, the resulting motivation to learn is not specific to science subjects, but only a, albeit highly desirable, side effect of teaching. Thus, one could argue that such approaches can be seen as a 'cheap trick' in order to sweeten empathisers' science learning. Emotional interaction with peers and teachers makes them swallow the bitter science pill, so to say.

Though this is, of course, an over-simplification, the question remains, if science contents provide genuine contexts that foster emotional empathising. Nobody expects empathic reactions to Newton's laws, for example. Most likely, one would attribute such an effect to biology, because this subject deals with living beings. However, one of our own recent studies (Zeyer, 2017) showed no coupling at all between empathy and motivation to learn biology. This result is less astonishing than one might think at first glance because empathy in its proper sense targets fellow humans. In Switzerland, where the study was conducted, human biology takes only a small place in the biology curriculum. It is an interesting question, if an anthropomorphic approach to animals and plants could support empathic reactions. However, in school biology, anthropomorphisms are usually not discussed though there might be good argument for braking this taboo (cf., Zohar & Ginossar, 1998).

Socio-scientific issues, as the name suggests, may be much more appropriate for providing genuine scientific contexts that foster empathising. Sadler and Zeidler (2005) define them as 'open-ended, ill-structured, debatable problems subject to multiple perspectives and solutions. The negotiation and resolution of such complex problems can be characterised generally by the process of informal reasoning' (p. 113). In the context of this paper, it is particularly important that informal reasoning, as Sadler and Zeidler point out, includes an emotive aspect that 'can be described by a care perspective in which empathy and concern for the well-being of others guided decisions or courses of action' (ibid., p. 122).

In the next section we will essentially argue along this line, namely that it is the personal and social character of socio-scientific issues, their *human factor*, so to speak, as well as the intrinsic inclusion of care and empathy in reasoning, that make socio-scientific issues particularly apposite for empathising – much more so than classical physics' laws, chemical reactions or biological concepts. We further suggest that this *human factor* is particularly prominent in health and environmental contexts, and that it can, at least partly, explain why these topics regularly appear in the top-ten lists of students' favourite science topics.

4.2. Environment and health as students' favourite topics

Key studies of students' most favoured science topics consistently identify health and environmental contexts. The most well-known of these studies is the OECD's Programme for International Student Assessment (PISA). PISA involves a survey every three years that measures 15-year-olds' competencies in reading literacy, mathematics literacy, and science literacy. In 2006, science was the primary domain to be assessed in special depth. 57 countries participated including 30 OECD countries and 27 non-OECD countries.

Of particular interest to this study is the fact that the 2006 PISA survey gathered data on students' interest in science, and responsibility towards resources and environments (e.g. Bybee, 2012). Table 1 shows some of the PISA 2006 Science results: the ten topics that most interested students. Strikingly, all these topics deal with health and medicine.

Table 1. The ten topics in which students showed the most interest (Bybee, 2012).

OECD rank	Non-OECD	Question label	Topic (How much interest do you have in the following information?)
1	1	Fit for drinking QNc	Learning which diseases are transmitted in drinking water
2	2	Sun and health QNa	Knowing how sunlight causes skin cancer
3	5	Physical exercise QNa	Understanding better how exercise affects your muscles
4	4	Good vibrations QNa	Knowing your own hearing sensitivity by having it checked
5	3	Physical exercise QNb	Learning how your body controls your breathing rate during physical exercise
6	18	Airbags Q9Na	Knowing why airbags can be dangerous in some accidents
7	7	Good vibrations QNb	Knowing how your hearing is damaged by loud noise
8	9	Alex's band QNa	Understanding how much can damage your hearing
9	6	Mousepox QNc	Understanding better how the body defends itself against viruses
10	11	Tobacco smoking QNc	Learning how the body recovers after stopping smoking

Commentators usually explain this phenomenon in terms of personal concern and personal experience (e.g. Bybee, 2012). The empathy perspective adds a slightly different view to this interpretation. Health and environment issues may not only trigger self-concern and interest, they could also satisfy the empathic desire to help others.

Indeed, there is evidence that empathising leads to genuinely altruistic behaviour (e.g. Stueber, 2017). We are well aware that this link has often been challenged as too simplistic (Bloom, 2017). Indeed, from a scientific point of view, the connection is not intrinsic, as Singer and Lamm (2009) point out. In competitive environments, successful tactics may involve using empathy to cause negative affective effects in opponents, and too much empathy may lead to selfish instead of other-oriented behaviour (ibd.).

Nevertheless, in social psychology and moral philosophy, it is generally assumed that, to a certain degree, empathy is causally involved in creating prosocial attitudes and behaviours. This is known as the *empathy-altruism thesis*. It is based on a series of carefully designed experiments suggesting that empathy/sympathy/compassion do indeed lead to genuinely altruistic motivation rather than to helping behaviour because of predominantly egoistic motivations (Stueber, 2017, p. 3)

4.3. The RoSE study – affective theory of mind

Another large-scale study, conducted at approximately the same time as PISA 2006, tells us more about the influence of gender. The RoSE (Relevance of Science Education) study was an international comparative project (Schreiner & Sjøberg, 2004) which investigated affective factors of importance to the learning of science and technology (S&T) in students. Participating students were towards the end of secondary school, that is, around 15-years-old.

One of the most salient and widely cited results of RoSE is depicted in Table 2. It presents the top five items that boys would like to learn about in science, and the top five for girls. All five girls' top items are connected to health and medicine, whereas none of the boys' top five items are.

From an empathy theory point of view, all five girls' top items allow for affective ToM. Of course, they can be treated as purely medical and scientific topics, however, they all have a vast psychological and social connotation. It is not astonishing that these are the girls' favourite topics. As Noddings and Brooks (2017) point out, the caring relation is close to female experience, and care ethics as a moral theory is rooted in the experience of women.

Table 2. Top five items boys would like to learn about science and the top five for girls (Schreiner & Sjøberg, 2004).

Boys	Girls
Explosive chemicals	Why we dream when we are sleeping and what the dreams might mean
How it feels to be weightless in space	Cancer – what we know and how we can treat it
How the atom bomb functions	How to perform first aid and use basic medical equipment
Biological and chemical weapons and what they do to the human body	How to exercise the body to keep fit and strong
Black holes, supernovae and other spectacular objects in outer space	Sexually transmitted diseases and how to be protected against them

However, again, the E-S theory helps both to explain gender differences and, at the same time, to relativise them. Indeed, on the one hand, because girls are, on average, more empathising than boys, the GSEM model predicts that accentuating empathising features in science learning will favour girls. However, empathising boys will also feel supported. They would be unlikely to favour the boys' favourite topics such as chemical explosions or the functioning of the atomic bomb. Generally, the boys' favourite items seem to suggest a certain indifference towards empathising qualities and, thus, they are likely to repel empathising boys – a considerable male minority. So, the E-S theory warns us against teaching all boys *boys'* content, and all girls *girls'* content.

These considerations find support in a third well-known study, 'Science in my Future' (Haste, 2004) commissioned by the Nestlé Social Research Programme and involving a representative sample of 704 young people aged 11–21 years' old across the UK, to identify their views and interests in science. Haste (2004, p. 5) writes:

> We found that overall, young people are quite supportive of scientific developments, but they are very sensitive to ethical issues and to claims that science and a 'scientific way of knowing' can be widely applied to human and social problems. However, contrary to what might be expected, questioning science does NOT appear to be the prerogative only of those who are uninterested in science. The strongest critique and scepticism came from those most interested in science – particularly and strikingly from girls.

The statement supports the ideas that an empathising approach to a scientific issue does *not* exclude a genuine scientific interest. The GSEM model again supports and explains this finding because the GSM path and the GEM path are parallel and do not structurally interfere with each other. In this context it is particularly interesting to note that new studies, including our own research, suggest that the systemising and the empathising cognition are independent from each other (Svedholm-Häkkinen & Lindeman, 2016). This development moves on from Baron-Cohen et al.'s original assumption, which postulated a negative correlation between the E and the S scores, i.e. that high systemisers were low empathisers and *vice versa*. It seems that this pattern is only true in autism populations and their relatives, who Baron-Cohen et al. initially focused on. In their non-autism random sample, Svedholm-Häkkinen and Lindeman (2016) identify—besides Baron-Cohen's empathisers (E > S), systemisers (S > E) and balanced type people (E = S)—two other groups. *High/high* people excel in both empathising and systemising, while *low/low* people, in contrast, are low empathisers and low systemisers.

The GSEM model predicts that *high/high* students, the ones who are highly systemizing and also highly empathizing, are predestined to be both highly motivated to learn science and highly motivated to take an ethical (human, social) perspective on scientific issues. Notice again, that, statistically, *high/high* students are girls as well as boys. So, not astonishingly, Haste writes:

> Girls are not so much less interested in science than boys; almost exactly the same proportion of girls as boys – about a third – would be interested in jobs related to science. But girls focus on different things. (2004, p. 3)

What are the 'different things' that girls focus on? They were clustered in a value set that Haste labelled as *Green*. The *Green* construct was 'about the environment, ethical issues concerned with animal experimentation, and concern about the pace of science and interfering with nature. It also includes items relating to feeling effective about being involved with the community' (2004, p. 10). It is not difficult to see in this description many empathising aspects.

4.4. Environmental depression – cognitive theory of mind

Here we use an indirect argument to convey that, sometimes, ignoring students' empathic reactions can – unintentionally – compromise teaching goals. Notice that this does not necessarily entail the inverse conclusion, that empathy must always be part of science learning. A critical account of this assumption is part of this section.

The example we use is concerned with cognitive ToM, that is, thinking about the thoughts of other people. This type of empathy has been identified in investigations about students' latent *environmental depression* (Zeyer & Kelsey, 2013). This term describes a constellation in which, on face value, the students can accurately reproduce required environmental facts yet they experience growing resignation because they are deeply pessimistic about the environmental future in general and their personal impact on it in particular.

In the 1990s, Sobel (1996) coined the term *ecophobia* to describe 'a kind of despondency' and 'a submerging of children's natural interests in a sea of problems' which he had observed among elementary school students who had participated in curriculum activities focusing on rainforest destruction. Almost 20 years later, in a systematic discourse analysis of Swiss students' classroom discussions, Zeyer and Roth (2013) showed how ecophobia can turn into environmental depression if an eco-scientist classroom discourse clashes with students' personal cognitive ToM. The eco-scientist discourse (Zeyer, 2008), progressive for its time, argues that scientific understanding of nature entails environmentally friendly behaviour. It always begins by describing the scientific background of an environmental issue and possible consequences of ignoring it. Lessons usually progress then to establishing norms for environmentally safe behaviour, and appeal to students' personal commitment and societal engagement.

In contrast to this strategy, the Swiss students, as it turned out, mostly did not believe that they could personally influence what happens to the environment. Their position was that young people had no influence at all on environmental matters. Discourse analysis revealed the reason for this stunning lack of self-efficacy: a deeply rooted cognitive ToM about other people. The students were convinced that most people did not care about the environment nor would they join pro-environmental initiatives. Other people were ready to break environmental rules and did not (or did not want to) understand the importance of environmental issues, and thus constantly undermined all pro-environmental efforts. Generally, these students said, it was too late for young people to engage in environmental issues. The final environmental break down was unavoidable: 'Live as long as you can and enjoy life. And that's it', was the frank motto of one of the interviewed students.

5. Should empathy play a role in science education?

In the previous section, we showed that science education research offers many opportunities to integrate empathising approaches at all levels. We have also attempted to show that health and environmental issues can be particularly suitable to open the empathising door to motivation to learn science, not only on an emotional, but also on a cognitive level.

In this section, we argue that there are good reasons why empathy should indeed be explicitly included in science education. We use the term Science|Environment|Health, which stands for a new pedagogical approach in science education. Finally, we will state that in this framework, empathy finds a natural and important role that makes it indispensable for the learning process. However, before focusing on these issues, it should become transparent why some *caveats* need to be taken into account.

5.1. Reasons to be cautious

Historically, empathy was conceived of as an alternative or even an antithesis to scientific thinking. Actually,

> […] various philosophers spoke throughout the 19th century and the second half of the 18th century about our (informal) ability to 'feel into' works of arts and into nature. Particularly the romantic thinkers, such as Herder and Novalis, viewed our ability to feel into nature as a vital corrective against the modern scientific attitude of merely dissecting nature into its elements; instead of grasping its underlying spiritual reality through a process of poetic identification. (Stueber, 2017, p. 2)

At the beginning of the twentieth century, empathy was conceived of as a non-inferential and non-theoretical method of grasping the content of other minds, and it became closely associated with the concept of understanding. Understanding (*Verstehen*) came to be the core concept of the hermeneutic tradition of philosophy, which was fundamentally distinguished from the method of explanation used in the natural sciences (ibid.).

Later, this identification of empathy and understanding and the associated claim that empathy is the sole and unique method of the human sciences faced heavy criticism. It was the beginning of a decline of the empathy concept and its subsequent disregard by philosophers of the human and social sciences in both the analytic and continental/hermeneutic tradition of philosophy, as Singer and Lamm (2009, p. 89) write:

> Within both traditions, proponents of empathy were—for very different reasons—generally seen as advocating an epistemically naïve and insufficiently broad conception of the methodological proceedings in the human sciences. As a result, most philosophers of the human and social sciences maintained their distance from the idea that empathy is central for our understanding of other minds and mental phenomena. For the rest of the century, empathy was almost entirely neglected philosophically.

Only at the beginning of the twenty-first century did a newly awakened scientific interest in empathy from developmental and social psychologists, and philosophers of mind, arise. These developments bolster and justify our attempt, with due caution, to point out that empathy has much to offer effective science teaching.

The claim that an empathic approach to nature is fundamentally different from a scientific approach can be understood in this historic context. Such claims manifest themselves in statements such as: 'Good science is value-free'. In school curricula, science is often depicted as neutrally objective and scientific understanding is characterised as independent from humanness and culture (Corrigan, Dillon, & Gunstone, 2007). This is certainly not true when it comes to teaching controversial issues. As Noddings and Brooks (2017) point out, critical thinking – if this capacity is to be used for the common good – must be guided by moral commitment, which is itself rooted in empathy, sympathy and caring (see below).

5.2. Science|Environment|Health – a Target for both Cognitions

The *good science is value-free* approach also led to the construction of an antinomy between natural sciences on the one hand, and environmental protection and health promotion, on the other (e.g. Zeyer, 2012). The health promotion field in particular has been dominated by this presumed antinomy for decades. A gap opened up between the culture of science and the culture of health promotion which frequently resulted in contesting and even in some cases neglecting the role of scientific knowledge in these areas (Hafen, 2007). On the other hand, although there has been some quite promising research about health topics in science education (Zeyer et al., 2009), the role of health and health education in science education has always and still remains unclear (Harrison, 2005).

In Europe, during the last decade, under the label Science|Environment|Health (Dillon, 2012), a new science pedagogy was posited to improve the situation (Zeyer & Kyburz-Graber, 2012). The basic assumption of this approach is that the antinomy described above is ill-informed and that, in reality, there is an essential potential of mutual benefit between these three interdependent educational fields (e.g. Zeyer & Dillon, 2014).

The GSEM model sheds a new and interesting light on the strength of this approach. On the one hand, health and environmental contexts are particularly helpful to spark emotional and cognitive empathising. On the other, fostering a decidedly scientific point of view helps teachers take into account and serve the systemising needs of the students, too. Thus, a Science|Environment|Health approach in science teaching provides a target for both cognitions.

While much of the early Science|Environment|Health research focused on socio-cultural links between science and health education, it is only in recent times that people have realised that the relation between medicine and science may be an even more powerful and almost completely unexploited resource for science education (Zeyer, Levin, & Keselman, 2015). Indeed, not only biology education, but also physics (for example, through physiology), and chemistry (for example, through biochemistry or toxicology) have strong contextual relations to medicine. Indeed, there seems to be even more potential for mutual benefit between medicine and science education than for health and science education.

5.3. Empathy is vital in controversial Science|Environment|Health issues

A common trait of Science|Environment|Health issues is that they are highly controversial. Traditionally, teachers have been recommended to adopt a neutral chair approach when teaching about controversial issues. However, Oulton, Dillon, and Grace (2004) suggest that such an approach is unethical in that all their pedagogic decisions would reflect the teachers' own position in some way and that it is better for them to be open and transparent about their position.

Based on Lynch and McKenna (1990), who argue that we see the world using our own particular schemata or worldview, and that this view is 'built up from birth in response to our social and cultural interactions with the world, formally and purposely through education, and erratically through experience' (p.412), Dillon et al. suggest the following approach to controversial issues in science education:

(1) a focus on the nature of controversy and controversial issues; that is, that people disagree; have different worldviews, value and limitations of science, political understanding, power, and so on;
(2) motivation for pupils to recognise the notion that a person's stance on an issue will be affected by their worldview;
(3) an emphasis on the importance of teachers and learners reflecting critically on their own stance and recognises the need to avoid the prejudice that comes from a lack of critical reflection;
(4) to give pupils skills and abilities to identify bias for themselves, encouraging them to take a critical stance towards claims of neutrality, a lack of bias and claims to offer a balanced view;
(5) to promote open mindedness, a thirst for more information and more sources of information and a willingness to change one's view as appropriate, and avoid strategies that encourage pupils to actually make up their minds on an issue too hastily; and,
(6) to motivate teachers, as much as possible, to share their views with pupils and make explicit the way in which they arrive at their own stance an issue.

This pedagogical approach requires the ability to empathise on all three levels, that is, emotionally, on the level of affective ToM, and of cognitive ToM as well. In controversial Science|Environment|Health contexts, empathising capacities are not only desirable, but indeed vital, for students and for science teachers too.

This conclusion may possibly be surprising, but it is in line with Noddings and Brooks (2017). These authors do not question that teaching controversial issues must use reason 'to ascertain and make judgments about facts' (p. 14). However, they advocate that children must be educated to act as moral agents. For this they need to learn to empathise and to take ethical concerns into account.

Thus one way to bring empathising qualities into the science classroom discourse is to include values. Values are a crucial dimension of controversial issues. As we see it, teaching Science|Environment|Health topics necessarily involves teaching about values.

5.4. The Values Approach in Science|Environment|Health

A values-based approach is rarely associated with school science. However, in Science|Environment|Health issues, the inclusion of a value discourse seems critical. There are examples of a values-based pedagogy linking science education and environmental education which offer some lessons which might have a wider applicability particularly when we look beyond the traditional school setting. Dillon (2007, p. 79) notes that 'Whereas values are usually implicit rather than explicit in much school science education, some environmental study centres deliberately promote a range of personal, communal and environmental values'. In their case study of Minstead Study Centre, Dillon and

Table 3. Conceptual framework emerging from the interview analysis (Dillon & Reid, 2016, p. 79).

Code	Explanation
Values	Underpinning assumptions and beliefs
Metaphors	Comparison between ideas seemingly unrelated
Issues	Environmental or scientific concerns
Activities	Tasks undertaken by students
Strategies	Generic pedagogical approaches
Outcomes	The end product of the activities

colleagues established a conceptual framework which emerged from interviews with the two key staff, Chris and Jane, presented in Table 3.

In this extract from an interview with Jane, the inter-relationship between the different dimensions of the pedagogical approach are made explicit through the coding process. The integration of content, pedagogic approach and underpinning values is readily apparent.

> Jane: I think the simple fact of going into the woods for their first immersion activity, 'Into The Wild Woods', you are allowing them that opportunity to immerse [STRATEGY], and appreciate tranquillity and the natural environment and just the beauty of surroundings - to allow this opportunity and then putting it forward as this is something to value [VALUE]. If you are going to be quiet in it, you will appreciate more [STRATEGY]. If your behaviour is such that you allow yourself to be receptive, then the children, I think, can absorb more of that [STRATEGY]. And the style of the way that Chris would work with them in the woods is kind of setting the tone of how we would expect the children to listen to us and respect us and listen to each other in the circle – the 'circle of equality' [STRATEGY]. And most of our activities are based on this kind of circle of equality [STRATEGY]. So, the teacher has a say but the children have a say too [VALUE], and they have got a place to contribute to that [STRATEGY] […] And I think, when they are coming back to the building, we take on board more the idea that the planet is threatened [ISSUE], and talk through various scenarios of how the planet has got a headache or back ache, eczema or whatever [METAPHOR]. And the children could be, should be, valuing the planet [OUTCOME], and they have a part to play in its recovery or remediation, whatever [VALUE]. And so, when they are first back here I would be talking about reducing, reusing and recycling as ways to solving some of the burgeoning problems that are ahead [STRATEGY]. And I put the problems down to mankind [ISSUE]. I say it is mankind that is mucking up this delicate equation [VALUE].

Values, metaphors, issues, activities, strategies and outcomes seem to be powerful ways of opening up spaces for discussing and debating new and exciting trends in science, citizenship and environmental education in a range of educational contexts.

In practical philosophy, a stance that constructively combines a conceptual and a value perspective is called *reflective equilibrium* (Daniels, 1979). The reflective equilibrium is a concept that goes back to the philosophy of Goodman and Rawls and is used in applied ethics both as a decision-making procedure and as a research paradigm. Ultimately, it reflects a basic assumption of Kant's Philosophy, according to which knowledge emerges from an interplay of fundamental principles and concepts on the one hand (*Verstehen*), and the intuitive perception of the world (*Anschauung*) (DePaul & Ramsey, 1998). The reflective equilibrium tries to adjust concepts and value judgments alternately in reflection, in such a way that coherence develops. This coherence can be conclusive, or it can be selective and then demands constant further development. Such an approach might be the basis of future developments of a values-based pedagogical approach to science education.

5.5. Conclusion: complexity and science for all

Often, it is complexity that entails controversial decisions, because, in complex contexts, scientific prediction in a classical sense is not possible. Fensham (2012) points out that non-complex contexts are still much too prominent in science education. He observes that humanity is locked 'in a complexity race' (p. 21), and concludes that Science|Environment|Health issues in their full complexity should be much more prominently represented in science teaching.

Abd-El-Khalick and Zeidler (2015) are arguing similarly when writing that 'the scale and complexity of the current, most urgent scientific questions and problems cross national boarders, and cut across localised agendas'. Referring to issues like global climate change, energy production and consumption, ecological maintenance and restoration, bioinformatics, and worldwide health threats, they write that 'science educators are compelled to face questions and challenges of a global nature, and of increasing importance and complexity' (p. 265).

In Science|Environment|Health contexts, the *human factor* is often the reason for complexity and successful dealing with complexity always involves empathy. Thus, empathising is not only tolerated as an attracting factor for empathisers but it is actually essential for wise decision making.

When opting for this opportunity, the danger is to get trapped into the other corner of the *good science is value-free* misunderstanding – that is to forget about systematic science. This fallacy has been described above in the context of health education. Actually, applying science in complex contexts is usually neither trivial nor straightforward, but requires high systemising abilities. The intrinsic limits of *prediction and control* in complex systems can entice people into devaluing the role of systemising. It is then tempting to discard scientific argumentation and to escape into normative attitudes, disguised by science talk.

Reflective equilibrium is a useful framework for coping with this challenge because it strictly asks for combining systemising and empathising approaches on a level playing field, and for permanently reflecting value judgements on scientific concepts and *vice versa*. In this constellation, both 'gates' to motivation for learning science are wide open. Such an approach promises to involve all students, be they systemisers or empathisers, and even more so the *high/high* students, who excel in both cognitive dimensions. In other words, what we propose is a genuine *science for all* approach.

Disclosure statement

No potential conflict of interest was reported by the authors.

ORCID

Albert Zeyer http://orcid.org/0000-0003-4297-0753
Justin Dillon http://orcid.org/0000-0001-5154-8306

References

Abd-El-Khalick, F., & Zeidler, D. L. (2015). New horizons for the journal of research in science teaching. *Journal of Research in Science Teaching*, *52*(3), 263–267. doi:10.1002/tea.21216

Baron-Cohen, S., Knickmeyer, R. C., & Belmonte, M. K. (2005). Sex differences in the brain: Implications for explaining autism. *Science*, *310*(5749), 819–823. doi:10.1126/science.1115455

Baron-Cohen, S., & Wheelwright, S. (2004). The empathy quotient: An investigation of adults with asperger syndrome or high functioning autism, and normal sex differences. *Journal of Autism and Developmental Disorders*, *34*(2), 163–175.

Baron-Cohen, S., Wheelwright, S., Stone, V., & Rutherford, M. (1999). A mathematician, a physicist and a computer scientist with asperger syndrome: Performance on folk psychology and folk physics tests. *Neurocase*, *5*, 475–483.

Bloom, P. (2017). *Against empathy: The case for rational compassion*. London: Bodley Head.

Bryan, R. R., Glynn, S. M., & Kittleson, J. M. (2011). Motivation, achievement, and advanced placement intent of high school students learning science. *Science Education*, *95*(6), 1049–1065. doi:10.1002/Sce.20462

Bybee, R. (2012). Scientific literacy in Environmental and Health Education. In A. Zeyer, & R. Kyburz-Graber (Eds.), *Science|Environment|Health. Towards a renewed pedagogy for science education* (pp. 49–67). Dordrecht: Springer.

Corrigan, D., Dillon, J., & Gunstone, R. (2007). *The Re-emergence of values in the science curriculum*. Rotterdam: Sense Publishers.

Daniels, N. (1979). Reflective equilibrium and theory of acceptance in ethics. *The Journal of Philosophy*, *76*(5), 256–282.

DePaul, M. R., & Ramsey, W. M. (1998). *Rethinking intuition: The psychology of intuition and its role in philosophical inquiry*. Studies in epistemology and cognitive theory. Lanham, MD: Rowman & Littlefield.

de Vignemont, F., & Singer, T. (2006). The empathic brain: How, when and why? *Trends in Cognitive Sciences*, *10*(10), 435–441. doi:10.1016/j.tics.2006.08.008

Dillon, J. (2007). An organic intellectual? On science, education, and the environment. In K. Tobin , & W.-M. Roth (Eds.), *The Culture of Science Education: Its History in Person* (pp. 311–322). Rotterdam: Sense Publishers.

Dillon, J. (2012). Science, environment and health education: Towards a reconceptualisation of their mutual interdependences. In A. Zeyer, & R. Kyburz-Graber (Eds.), *Science|Environment|Health: Towards a renewed pedagogy for science education* (pp. 87–101). Dordrecht: Springer.

Dillon, J., & Reid, A. (2016). Science, the environment and citizenship: Teaching values at Minstead Study Centre. In *The selected works of Justin Dillon* (pp. 205–217). London: Taylor and Francis.

Dvash, J., & Shamay-Tsoory, S. G. (2014). Theory of mind and empathy as multidimensional constructs. *Topics in Language Disorders*, *34*(4), 282–295.

Fensham, P. J. (2012). Preparing citizens for a complex world: The grand challenge of teaching socio-scientific issues in science education. In A. Zeyer, & R. Kyburz-Graber (Eds.), *Science|Environment|Health. Towards a renewed pedagogy for science education* (pp. 7–29). Dordrecht: Springer.

Hafen, M. (2007). *Mythologie der Gesundheit. Zur Integration von Salutogenese und Pathogenese* [Mythology of health: Towards the integration of salutogenesis and pathogenesis]. Heidelberg: Carl Auer Verlag.

Harrison, J. K. (2005). Science education and health education: Locating the connections. *Studies in Science Education*, *41*(1), 51–90.

Haste, H. (2004). *Science in My future: A study of values and beliefs in relation to scienceand technology amongst 11–21 year olds*. London: Nestlé Social Research Programme.

Itzek-Greulich, H., & Vollmer, C. (2017). Emotional and motivational outcomes of lab work in the secondary intermediate track: The contribution of a science center outreach lab. *Journal of Research in Science Teaching*, *54*(1), 3–28. doi:10.1002/tea.21334

Keller, M. M., Neumann, K., & Fischer, H. E. (2016). The impact of physics teachers' pedagogical content knowledge and motivation on students' achievement and interest. *Journal of Research in Science Teaching*, 1–29. doi:10.1002/tea.21378

Lynch, D., & McKenna, K. (1990). *Room to dream*. New York: Canongate Books.
Martin, A. J., Durksen, T. L., Williamson, D., Kiss, J., & Ginns, P. (2016). The role of a museum-based science education program in promoting content knowledge and science motivation. *Journal of Research in Science Teaching*, *53*(9), 1364–1384. doi:10.1002/tea.21332
Noddings, N., & Brooks, L. (2017). *Teaching controversial issues: The case for critical thinking and moral commitment in the classroom*. New York: Teachers College Press.
Oulton, C., Dillon, J., & Grace, M. M. (2004). Reconceptualizing the teaching of controversial issues. *International Journal of Science Education*, *26*(4), 411–423.
Polman, J. L., & Hope, J. M. G. (2014). Science news stories as boundary objects affecting engagement with science. *Journal of Research in Science Teaching*, *51*(3), 315–341. doi:10.1002/tea.21144
Sadler, T. D., & Zeidler, D. L. (2005). Patterns of Informal Reasoning in the Context of Socioscientific Decision Making. *Journal of Research in Science Teaching*, *42*(1), 112–138.
Schreiner, C., & Sjøberg, S. (2004). Sowing the seeds of ROSE: Background, rationale, questionnaire development and data collection for ROSE (Relevance of Science Education) – a comparative study of students' views of science and science education. *Acta Didactica*, *4*, 1–20.
Simpkins, S. D., Price, C. D., & Garcia, K. (2015). Parental support and high school students' motivation in biology, chemistry, and physics: Understanding differences among latino and caucasian boys and girls. *Journal of Research in Science Teaching*, *52*(10), 1386–1407. doi:10.1002/tea.21246
Singer, T., & Lamm, C. (2009). The social neuroscience of empathy. *Annals of the New York Academy of Sciences*, *1156*, 81–96.
Sobel, D. (1996). *Beyond Ecophobia*. Great Barrington: The Orion Society.
Stueber, K. (2017). Empathy. In E. N. Zalta (Ed.), *The stanford encyclopedia of philosophy* (Spring 2017 Edition). https://plato.stanford.edu/archives/spr2017/entries/empathy/
Svedholm-Häkkinen, A. M., & Lindeman, M. (2016, March). Testing the empathizing-systemizing theory in the general population: Occupations, vocational interests, grades, hobbies, friendship quality, social intelligence, and sex role identity. *Personality and Individual Differences*, *90*, 365–370. doi:10.1016/j.paid.2015.11.044
Svedholm-Häkkinen, A. M., Ojala, S. J., & Lindeman, M. (2018). Male brain type women and female brain type men: Gender atypical cognitive profiles and their correlates. *Personality and Individual Differences*, 122 (August 2017), 7–12. doi:10.1016/j.paid.2017.09.041
Wright, D. B., & Skagerberg, E. M. (2012). Measuring empathizing and systemizing with a large US sample. *PLoS ONE*, *7*(2). doi:10.1371/journal.pone.0031661
Zeyer, A. (2008). Students' post-ecological Discourse in a Secondary One STSE (Science-Technology-Society-Environment) Education. *Proceedings of the NARST 2008 Annual Meeting*, Baltimore, MD, USA.
Zeyer, A. (2012). What is a potential scientist? Motivation to learn science – a question of culture or of cognition? In S. Markic, I. Eilks, D. di Fuccia, & B. Ralle (Eds.), *Issues of heterogenitiy and cultural diversity in science education and science education research* (pp. 53–58). Aachen: Shaker Verlag.
Zeyer, A. (2017). Gender, complexity, and science for all: Systemizing and its impact on motivation to learn science for different science subjects. *Journal of Research in Science Teaching*, *55*(2), 147–171. doi:10.1002/tea.21413
Zeyer, A., Çetin-Dindar, A., Md Zain, A. N., Juriševič, M., Devetak, I., & Odermatt, F. (2013). Systemizing: A cross-cultural constant for motivation to learn science. *Journal of Research in Science Teaching*, *50*(9), 1047–1067. doi:10.1002/tea.21101
Zeyer, A., & Dillon, J. (Eds.). (2014). Science|Environment|Health—Towards a reconceptualization of three critical and inter-linked areas of education. *International Journal of Science Education*, *36*(9). Special Issue. doi:10.1080/09500693.2014.904993
Zeyer, A., & Kelsey, E. (2013). Environmental Education in a Cultural Context. In R. B. Stevenson, M. Brody, J. Dillon, & A. E. J. Wals (Eds.), *International Handbook of Research on Environmental Education* (pp. 206–212). New York and London: Routledge.
Zeyer, A., & Kyburz-Graber, R. (Eds.). (2012). *Science|Environment|Health. Towards a renewed pedagogy for science education*. Dordrecht, Boston, London: Springer Verlag. doi:10.1007/978-90-481-3949-1

Zeyer, A., Levin, D. M., & Keselman, A. (2015). For the mutual benefit: Health information provision in a science classroom. In C. Arnott Smith & A. Keselman (Eds.), *Meeting health information needs outside of healthcare* (pp. 114–131). Oxford: Witney.

Zeyer, A., & Odermatt , F. (2009). Gesundheitskompetenz (Health Literacy) - Bindeglied zwischen Gesundheitsbildung und naturwissenschaftlichem Unterricht. *Zeitschrift Für Didaktik der Naturwissenschaften*, *15*, 265–285.

Zeyer, A., & Roth, W. M. (2013). Post-ecological discourse in the making. *Public Understanding of Science*, *22*(1), 33–48. doi:10.1177/0963662510394949

Zohar, S., & Ginossar, S. (1998). Lifting the taboo regarding teleology and anthropomorphism in biology education. Heretical suggestions. *Science Education*, *82*(6), 679–697.